OPEN-FILE REPORT 2000-005

SEISMIC HAZARD EVALUATION OF THE MT. BALDY 7.5-MINUTE QUADRANGLE, LOS ANGELES COUNTY, CALIFORNIA

2000

DEPARTMENT OF CONSERVATION
Division of Mines and Geology

STATE OF CALIFORNIA
GRAY DAVIS
GOVERNOR

THE RESOURCES AGENCY
MARY D. NICHOLS
SECRETARY FOR RESOURCES

DEPARTMENT OF CONSERVATION
DARRYL YOUNG
DIRECTOR

DIVISION OF MINES AND GEOLOGY
JAMES F. DAVIS, *STATE GEOLOGIST*

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PREFACE

With the increasing public concern about the potential for destructive earthquakes in northern and southern California, the State Legislature passed the Seismic Hazards Mapping Act in 1990. The purpose of the Act is to protect the public from the effects of strong ground shaking, liquefaction, landslides or other ground failure, and other hazards caused by earthquakes. The program and actions mandated by the Seismic Hazards Mapping Act closely resemble those of the Alquist-Priolo Earthquake Fault Zoning Act (which addresses only surface fault-rupture hazards) and are outlined below:

1. **The State Geologist** is required to delineate the various "seismic hazard zones."

2. **Cities and Counties**, or other local permitting authorities, must regulate certain development "projects" within the zones. They must withhold the development permits for a site within a zone until the geologic and soil conditions of the project site are investigated and appropriate mitigation measures, if any, are incorporated into development plans.

3. **The State Mining and Geology Board (SMGB)** provides additional regulations, policies, and criteria to guide cities and counties in their implementation of the law. The SMGB also provides criteria for preparation of the Seismic Hazard Zone Maps (Web site http://www.consrv.ca.gov/dmg/shezp/zoneguid/) and for evaluating and mitigating seismic hazards.

4. **Sellers (and their agents)** of real property within a mapped hazard zone must disclose at the time of sale that the property lies within such a zone.

As stated above, the Act directs the State Geologist, through the Division of Mines and Geology (DMG) to delineate seismic hazard zones. Delineation of seismic hazard zones is conducted under criteria established by the Seismic Hazards Mapping Act Advisory Committee and its Working Groups and adopted by the California SMGB.

The Official Seismic Hazard Zone Maps, released by DMG, which depict zones of required investigation for liquefaction and/or earthquake-induced landslides, are available from:

BPS Reprographic Services
149 Second Street
San Francisco, California 94105
(415) 512-6550

Seismic Hazard Evaluation Reports, released as Open-File Reports (OFR), summarize the development of the hazard zone map for each area and contain background documentation for use by site investigators and local government reviewers. These Open-File Reports are available for reference at DMG offices in Sacramento, San Francisco, and Los Angeles. Copies of the reports may be purchased at the Sacramento, Los Angeles, and San Francisco offices. In addition, the Sacramento office offers prepaid mail order sales for all DMG OFRs. **NOTE: The Open-File Reports are not available through BPS Reprographic Services.**

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Seismic Hazard Evaluation Reports and additional information on seismic hazard zone mapping in California are available on the Division of Mines and Geology's Internet homepage:
http://www.consrv.ca.gov/dmg/shezp/

INTRODUCTION

The Seismic Hazards Mapping Act (the Act) of 1990 (Public Resources Code, Chapter 7.8, Division 2) directs the California Department of Conservation, Division of Mines and Geology (DMG) to delineate seismic hazard zones. The purpose of the Act is to reduce the threat to public health and safety and to minimize the loss of life and property by identifying and mitigating seismic hazards. Cities, counties, and state agencies are directed to use the seismic hazard zone maps in their land-use planning and permitting processes. The Act requires that site-specific geotechnical investigations be performed prior to permitting most urban development projects within the hazard zones. Evaluation and mitigation of seismic hazards are to be conducted under guidelines established by the California State Mining and Geology Board (1997; also available on the Internet at http://www.consrv.ca.gov/dmg/pubs/sp/117/).

The Act also directs SMGB to appoint and consult with the Seismic Hazards Mapping Act Advisory Committee (SHMAAC) in developing criteria for the preparation of the seismic hazard zone maps. SHMAAC consists of geologists, seismologists, civil and structural engineers, representatives of city and county governments, the state insurance commissioner and the insurance industry. In 1991 SMGB adopted initial criteria for delineating seismic hazard zones to promote uniform and effective statewide implementation of the Act. These initial criteria provide detailed standards for mapping regional liquefaction hazards. They also directed DMG to develop a set of probabilistic seismic maps for California and to research methods that might be appropriate for mapping earthquake-induced landslide hazards.

In 1996, working groups established by SHMAAC reviewed the prototype maps and the techniques used to create them. The reviews resulted in recommendations that the 1) process for zoning liquefaction hazards remain unchanged and that 2) earthquake-induced landslide zones be delineated using a modified Newmark analysis.

This Seismic Hazard Evaluation Report summarizes the development of the hazard zone map for each area. The process of zoning for liquefaction uses a combination of Quaternary geologic mapping, historic high-water-table information, and subsurface geotechnical data. The process for zoning earthquake-induced landslides incorporates earthquake loading, existing landslide features, slope gradient, rock strength, and geologic structure. Probabilistic seismic hazard maps, which are the underpinning for delineating seismic hazard zones, have been prepared for peak ground acceleration, mode magnitude, and mode distance with a 10% probability of exceedance in 50 years (Petersen and others, 1996) in accordance with the mapping criteria.

This evaluation report summarizes seismic hazard zone mapping for potentially liquefiable soils and earthquake-induced landslides in the Mt. Baldy 7.5-minute Quadrangle (scale 1:24,000).

SECTION 1
LIQUEFACTION EVALUATION REPORT

Liquefaction Zones in the Mt. Baldy 7.5-Minute Quadrangle, Los Angeles County, California

By
Ralph Loyd

California Department of Conservation
Division of Mines and Geology

PURPOSE

The Seismic Hazards Mapping Act (the Act) of 1990 (Public Resources Code, Chapter 7.8, Division 2) directs the California Department of Conservation, Division of Mines and Geology (DMG) to delineate Seismic Hazard Zones. The purpose of the Act is to reduce the threat to public health and safety and to minimize the loss of life and property by identifying and mitigating seismic hazards. Cities, counties, and state agencies are directed to use the seismic zone maps in their land-use planning and permitting processes. The Act requires that site-specific geotechnical investigations be performed prior to permitting most urban development projects within the hazard zones. Evaluation and mitigation of seismic hazards are to be conducted under guidelines established by the California State Mining and Geology Board (1997; also available on the Internet at http://www.consrv.ca.gov/dmg/pubs/sp/117/).

This evaluation report summarizes seismic hazard zone mapping for potentially liquefiable soils in the Mt. Baldy 7.5-minute Quadrangle (scale 1:24,000). This section and Section 2 addressing earthquake-induced landslides, are part of a series that will summarize development of similar hazard zone maps in the state (Smith, 1996).

Additional information on seismic hazards zone mapping in California can be accessed on DMG's Internet homepage: http://www.consrv.ca.gov/dmg/shezp/

BACKGROUND

Liquefaction-induced ground failure has historically been a major cause of earthquake damage in southern California. During the 1971 San Fernando and 1994 Northridge earthquakes, significant damage to roads, utility pipelines, buildings, and other structures in the Los Angeles area was caused by liquefaction-induced ground displacement.

Localities most susceptible to liquefaction-induced damage are underlain by loose, water-saturated granular sediments within the upper 40 feet of the ground surface. These geological and ground-water conditions exist in parts of southern California, most notably in some densely populated valley regions and alluviated floodplains. In addition, the opportunity for strong earthquake ground shaking is high because of the many nearby active faults. The combination of these factors constitutes a significant seismic hazard in the southern California region in general, as well as in the Mt. Baldy Quadrangle.

SCOPE AND LIMITATIONS

Evaluation for potentially liquefiable soils is generally confined to areas covered by Quaternary sedimentary deposits. Such areas consist mainly of alluviated valleys, floodplains, and canyon regions. The evaluation is based on earthquake ground shaking, surface and subsurface lithology, geotechnical soil properties, and ground-water depth data, most of which are gathered from a variety of sources. The quality of the data used varies. Although selection of data used in this evaluation was rigorous, the state of California and the Department of Conservation make no representations or warranties regarding the accuracy of the data obtained from outside sources.

Liquefaction zone maps are intended to prompt more detailed, site-specific geotechnical investigations as required by the Act. As such, liquefaction zone maps identify areas where the potential for liquefaction is relatively high. They do not predict the amount or direction of liquefaction-related ground displacements, or the amount of damage to facilities that may result from liquefaction. Factors that control liquefaction-induced ground failure are the extent, depth and thickness of liquefiable sediments, depth to ground water, rate of drainage, slope gradient, proximity to free-face conditions, and intensity and duration of ground shaking. These factors must be evaluated on a site-specific basis to determine the potential for ground failure at any given project site.

Information developed in the study is presented in two parts: physiographic, geologic, and hydrologic conditions in PART I, and liquefaction potential, opportunity, susceptibility, and zoning evaluations in PART II.

PART I

STUDY AREA LOCATION AND PHYSIOGRAPHY

The Mt. Baldy Quadrangle covers an area of about 62 square miles of mostly mountainous terrain that straddles the Los Angeles and San Bernardino County boundary. At the foot of the mountains in the southern part of the quadrangle about 12 square miles of gently sloping land lies within the densely populated Pomona Valley. Most of the rugged terrain within the San Gabriel Mountains lies within the Angeles National Forest. Evaluation of liquefaction hazards is restricted to an area of about three square miles of gently sloping terrain, mostly in the City of Claremont, within the Los Angeles County portion of the Mt. Baldy Quadrangle. (Federal funding for the program limits the investigation to Los Angeles, Orange, and Ventura counties; therefore, the County of San Bernardino is not covered by the current study.)

Access to this area is primarily via a grid of city streets or Mt. Baldy Road that enters San Antonio Canyon near San Antonio Dam at the middle of the quadrangle. The area includes a very small part of the upper Santa Ana River valley, which is a 40-mile long, 10-mile wide structural basin extending along the southern base of the San Gabriel Mountains between Pomona and San Bernardino. The San Gabriel Mountains rise very abruptly from the valley and reach elevations of nearly 7000 feet near northern boundary of the quadrangle. The mountains are composed of a complex assemblage of Precambrian through Cretaceous igneous and metamorphic rocks that have been thrust to the south over the adjacent basins.

The major drainage emanating from the San Gabriel Mountains within the project area is San Antonio Creek. Sediments eroded from the mountains and deposited in the valley by this drainage and its tributaries have formed a large alluvial fan upon which the City of Claremont now lies. Additional drainages entering the valley include minor streams flowing from Chicken, Palmer, Cobal, Burbank, and Gail canyons. Due to land use restrictions, San Antonio Canyon north of San Antonio Dam was not evaluated for liquefaction hazard zoning.

GEOLOGIC CONDITIONS

Surface Geology

A Quaternary geologic map of the Mt. Baldy Quadrangle was obtained in digital form from the Southern California Areal Mapping Project [SCAMP] (1999). SCAMP nomenclature was used for labeling geologic units (Morton and Kennedy, 1989). The Quaternary geologic map of the Mt. Baldy Quadrangle is reproduced as Plate 1.1.

The Quaternary geologic map (Plate 1.1) shows that the valley terrain within the project area of the Mt. Baldy Quadrangle is covered entirely by deposits of a large alluvial fan formed by San Antonio Creek. The alluvial fan is composed primarily of sand, gravel, cobbles, and boulders that were derived from the crystalline rocks exposed in the San

Table 1

Gabriel Mountains.

The alluvial units developed by SCAMP and mapped within the Mt. Baldy Quadrangle have been subdivided into very old alluvial fan deposits (Qvof), older alluvial fan deposits (Qof), five generations of younger alluvial fan deposits (Qyf1 – Qyf5), and active alluvial fan deposits (Qf). Of these, only Qf, Qyf5, Qof, and Qvof are recognized within the evaluated Los Angeles County portion of the quadrangle (Plate 1.1, Table 1.1).

Map Unit	**Environment of Deposition**	**Age**
Qf	active alluvial fan	historic time
Qyf5	younger alluvial fan	late Holocene
Qof	older alluvial fan	later Pleistocene
Qvof	very old alluvial fan	earlier Pleistocene

Some unit names include the "characteristic grain size" (e.g. Qyf2a, Qofg), b: boulder gravel, g: gravel, a: arenaceous (sand), s: silty, c: clayey.

Table 1.1. Quaternary units mapped in the Los Angeles County part of the Mt. Baldy Quadrangle using the Southern California Areal Mapping Project (SCAMP) nomenclature.

Subsurface Geology and Geotechnical Characteristics

Unfortunately, no useful logs of geotechnical boreholes drilled within the three-square-mile project area were located during this study. However, non-technical logs of water wells drilled in the immediate area, as well as geotechnical logs of boreholes drilled into the San Antonio Creek alluvial fan in adjacent areas, provide limited information for use in estimating liquefaction potential. These data indicate that young Quaternary deposits in this area are no more than 30 feet thick and are dominated by gravel-, cobble-, and boulder-rich sand layers. The gravel and larger-size clast content commonly exceeds 50%, as indicated by geotechnical logs of boreholes drilled along Base Line Road just south of the project area. Locally, the data also indicate that interbedded sand-rich layers occur within the near-surface deposits. These sand layers are potentially liquefiable during earthquake shaking if the material is loosely packed and saturated.

GROUND-WATER CONDITIONS

Seismic hazard mapping for liquefaction focuses on areas where historical ground-water depths have been 40 feet or less. Accordingly, a ground-water evaluation was performed for the project area. Data required to conduct the evaluation were obtained from technical publications and water-well logs dating back to the turn-of-the-century. These included 1904 ground-water contour maps (Mendenhall, 1908), ground-water contour maps prepared by Carson and Matti (1985) based on water-well measurements between 1973 and 1979, and shallow ground-water maps included in Leighton and Associates (1990).

Shallow ground-water conditions in the project area were identified in a single one-square-mile area situated along the base of the San Gabriel Mountains (Plate 1.2). Here, near-surface sediments are frequently saturated by surface and subsurface waters flowing from San Antonio, Webb, Cobal, Palmer, and several smaller canyons. In addition, infiltrating water apparently accumulates as perched groundwater on the impervious bedrock surface interpreted to exist at shallow depth along this segment of the valley margin.

PART II

EVALUATING LIQUEFACTION POTENTIAL

Liquefaction occurs in water-saturated sediments during moderate to great earthquakes. Liquefied sediments are characterized by a loss of strength and may fail, causing damage to buildings, bridges, and other such structures. A number of methods for mapping liquefaction hazard have been proposed; Youd (1991) highlights the principal developments and notes some of the widely used criteria. Youd and Perkins (1978) demonstrate the use of geologic criteria as a qualitative characterization of susceptibility units, and introduce the mapping technique of combining a liquefaction susceptibility map and a liquefaction opportunity map to produce liquefaction potential. Liquefaction susceptibility is a function of the capacity of sediments to resist liquefaction and liquefaction opportunity is a function of the seismic ground shaking intensity. The application of the Seed Simplified Procedure (Seed and Idriss, 1971) for evaluating liquefaction potential allows a quantitative characterization of susceptibility of geologic units. Tinsley and others (1985) applied a combination of the techniques used by Seed and others (1983) and Youd and Perkins (1978) for mapping liquefaction hazards in the Los Angeles region. The method applied in this study for evaluating liquefaction potential is similar to that of Tinsley and others (1985), combining geotechnical data analyses, and geologic and hydrologic mapping, but follows criteria adopted by the California State Mining and Geology Board (in press).

LIQUEFACTION OPPORTUNITY

According to the criteria adopted by the California State Mining and Geology Board (in press), liquefaction opportunity is a measure, expressed in probabilistic terms, of the potential for ground shaking strong enough to generate liquefaction. Analyses of in-situ liquefaction resistance require assessment of liquefaction opportunity. The minimum level of seismic excitation to be used for such purposes is the level of peak ground acceleration (PGA) with a 10% probability of exceedance over a 50-year period. The earthquake magnitude is the magnitude that contributes most to the acceleration.

For the Mt. Baldy Quadrangle, a peak acceleration of 0.76 g resulting from an earthquake of magnitude 7.0 was used for liquefaction analyses. The PGA and magnitude values were based on de-aggregation of the probabilistic hazard at the 10% in 50-year hazard level (Petersen and others, 1996) and Cramer and Peterson (1996), respectively. See the ground motion portion (Section 3) of this report for further details.

LIQUEFACTION SUSCEPTIBILITY

Liquefaction susceptibility reflects the relative resistance of soils to loss of strength when subjected to ground shaking. Primarily, physical properties and conditions of soil such as sediment grain-size distribution, compaction, cementation, saturation, and depth govern the degree of resistance. These properties and conditions are correlated with geologic age and environment of deposition. With increasing age of a deposit, relative density may increase through cementation of the particles or the increase in thickness of the overburden sediments. Grain size characteristics of a soil also influence susceptibility to liquefaction. Sands are more susceptible than silts or gravels, although silts of low plasticity are treated as liquefiable in this investigation. Cohesive soils are generally not considered susceptible to liquefaction. Such soils may be vulnerable to strength loss with remolding and represent a hazard that is not addressed in this investigation. Soil characteristics and processes that result in lower liquefaction susceptibility generally result in higher penetration resistances to the soil sampler. Different blow count corrections are used for silty sand and nonplastic silt than for clean sand (Seed and others, 1985). Therefore, blow count or cone penetrometer values are a useful indicator of liquefaction susceptibility.

Saturation is required for liquefaction, and the liquefaction susceptibility of a soil varies with the depth to ground water. Very shallow ground water increases the susceptibility to liquefaction (more likely to liquefy). Soils that lack resistance (susceptible soils) are typically saturated, loose sandy sediments. Soils resistant to liquefaction include all soil types that are dry or sufficiently dense.

DMG's map inventory of areas containing soils susceptible to liquefaction begins with evaluation of geologic maps, cross-sections, geotechnical test data, geomorphology, and ground-water hydrology. Soil-property and soil-condition factors such as type, age, texture, color, and consistency, along with historic depths to ground water are used to identify, characterize, and correlate susceptible soils. Because Quaternary geologic mapping is based on similar soil observations, findings can be related in terms of the map units. DMG's qualitative susceptible soil inventory is summarized on Table 1.2.

Map Unit	Age	Environment of Deposition	Primary Textures	General Consistency	Susceptible to Liquefaction?*
Qf	latest Holocene	active alluvial fan deposits	sand, gravel, cobbles, boulder	very loose to loose	yes
Qyf5	Holocene	younger alluvial fan deposits	sand, gravel, cobbles, boulder	loose to moderately dense	yes
Qof	late Pleistocene	older alluvial fan deposits	sand, gravel, cobbles, boulder	dense to very dense	not likely
Qvof	Pleistocene	very old alluvial fan deposits	sand, gravel, cobbles, boulder	dense to very dense	not likely

* When saturated.

Table 1.2 General geotechnical characteristics and liquefaction susceptibility of Quaternary sedimentary deposits in the Los Angeles County portion of the Mt. Baldy Quadrangle.

Quantitative Liquefaction Analysis

No quantitative analysis of liquefaction potential using the Seed Simplified Procedure (Seed and Idriss, 1971; Seed and others, 1983; Seed and Harder, 1990, Youd and Idriss, 1997) was performed in the Los Angeles County portion of the Mt. Baldy Quadrangle because no useful geotechnical borehole logs were available. Consequently, other criteria adopted by the State Mining and Geology Board (in press) were applied in the seismic hazard zone mapping for liquefaction.

LIQUEFACTION ZONES

Criteria for Zoning

The areas underlain by late Quaternary geologic units were included in liquefaction zones using the criteria developed by the Seismic Hazards Mapping Act Advisory Committee and adopted by the California State Mining and Geology Board (in press). Under those criteria, liquefaction zones are areas meeting one or more of the following:

1. Areas known to have experienced liquefaction during historic earthquakes.

2. All areas of uncompacted fills containing liquefaction susceptible material that are saturated, nearly saturated, or may be expected to become saturated.

3. Areas where sufficient existing geotechnical data and analyses indicate that the soils are potentially liquefiable.

4. Areas where existing geotechnical data are insufficient.

In areas of limited or no geotechnical data, susceptibility zones may be identified by geologic criteria as follows:

a) Areas containing soil deposits of late Holocene age (current river channels and their historic floodplains, marshes and estuaries), where the M7.5-weighted peak acceleration that has a 10% probability of being exceeded in 50 years is greater than or equal to 0.10 g and the water table is less than 40 feet below the ground surface; or

b) Areas containing soil deposits of Holocene age (less than 11,000 years), where the M7.5-weighted peak acceleration that has a 10% probability of being exceeded in 50 years is greater than or equal to 0.20 g and the historic high water table is less than or equal to 30 feet below the ground surface; or

c) Areas containing soil deposits of latest Pleistocene age (between 11,000 years and 15,000 years), where the M7.5-weighted peak acceleration that has a 10% probability of being exceeded in 50 years is greater than or equal to 0.30 g and the historic high water table is less than or equal to 20 feet below the ground surface.

Application of SMGB criteria for liquefaction zoning in the Mt. Baldy Quadrangle is summarized below.

Areas of Past Liquefaction

No documented historic or paleoseismic liquefaction in the Mt. Baldy Quadrangle was found.

Artificial Fills

With the exception of the engineered San Antonio Dam, significant artificial fills were not mapped or identified in the Mt. Baldy Quadrangle.

Areas with Existing Geotechnical Data

Useful logs of geotechnical boreholes drilled within the project area were not located during this study.

Areas without Existing Geotechnical Data

One area, an elongate belt of land encompassing 0.82-square mile along the base of the San Gabriel Mountains in the northwestern part of the City of Claremont, is zoned for liquefaction. The boundaries of this zone extend southward into the adjoining Ontario Quadrangle, encompassing a total area of about one square mile. Zonation of this area is based on (1) criteria developed by the Seismic Hazards Mapping Act Advisory

Committee for areas lacking existing geotechnical data and (2) the likely occurrence of loose sandy alluvial deposits saturated by ground-water perched above a shallow, impervious bedrock surface. These sediments are also periodically saturated by surface and subsurface waters that emanate from adjacent canyons.

ACKNOWLEDGMENTS

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SECTION 2
EARTHQUAKE-INDUCED LANDSLIDE EVALUATION REPORT

Earthquake-Induced Landslide Zones in the Mt. Baldy 7.5-Minute Quadrangle, Los Angeles County, California

By
Florante G. Perez, Allan G. Barrows, Timothy P. McCrink, and Rick I. Wilson

California Department of Conservation
Division of Mines and Geology

PURPOSE

The Seismic Hazards Mapping Act (the Act) of 1990 (Public Resources Code, Chapter 7.8, Division 2) directs the California Department of Conservation, Division of Mines and Geology (DMG) to delineate Seismic Hazard Zones. The purpose of the Act is to reduce the threat to public health and safety and to minimize the loss of life and property by identifying and mitigating seismic hazards. Cities, counties, and state agencies are directed to use the seismic hazard zone maps in their land-use planning and permitting processes. The Act requires that site-specific geotechnical investigations be performed prior to permitting most urban development projects within the hazard zones. Evaluation and mitigation of seismic hazards are to be conducted under guidelines established by the California State Mining and Geology Board (1997; also available on the Internet at http://www.consrv.ca.gov/pubs/sp/117/).

This evaluation report summarizes seismic hazard zone mapping for earthquake-induced landslides in the Mt. Baldy 7.5-minute Quadrangle (scale 1:24,000). This section and Section 1 addressing liquefaction, are part of a series that will summarize development of similar hazard zone maps in the state (Smith, 1996). Additional information on seismic hazard zone mapping in California can be accessed on DMG's Internet homepage: http://www.consrv.ca.gov/dmg/shezp/

BACKGROUND

Landslides triggered by earthquakes have historically been a major cause of earthquake damage. Landslides triggered by the 1971 San Fernando, 1989 Loma Prieta, and 1994 Northridge earthquakes were responsible for destroying or damaging numerous homes and other structures, blocking major transportation corridors, and damaging various types of lifeline infrastructure. Areas most susceptible to earthquake-induced landslides are steep slopes in poorly cemented or highly fractured rocks, in loose soils, and on or adjacent to existing landslide deposits. These geologic and terrain conditions exist in many parts of California, most notably in hilly areas already developed or currently undergoing development. In addition, the opportunity for strong earthquake ground shaking is high because of the many nearby active faults. The combination of these factors constitutes a significant seismic hazard in the southern California region, which includes the Mt. Baldy Quadrangle.

SCOPE AND LIMITATIONS

The methodology used to make this map is based on earthquake ground-shaking estimates, geologic material-strength characteristics and slope gradient. These data are gathered primarily from a variety of outside sources; thus the quality of the data is variable. Although the selection of data used in this evaluation was rigorous, the State of California and the Department of Conservation make no representations or warranties regarding the accuracy of the data gathered from outside sources.

Earthquake-induced landslide zone maps are intended to prompt more detailed, site-specific geotechnical investigations as required by the Act. As such, these zone maps identify areas where the potential for earthquake-induced landslides is relatively high. Earthquake-generated ground failures that are not addressed by this map include those associated with ridge-top spreading and shattered ridges. No attempt has been made to map potential run-out areas of triggered landslides. It is possible that such run-out areas may extend beyond the zone boundaries. The potential for ground failure resulting from liquefaction-induced lateral spreading of alluvial materials, considered by some to be a form of landsliding, is not specifically addressed by the earthquake-induced landslide zone or this report. See Section 1, Liquefaction Evaluation Report for the Mt. Baldy Quadrangle, for more information on the delineation of liquefaction zones.

Information developed in the study is presented in two parts: physiographic, and geologic conditions in PART I, and ground shaking opportunity, landslide hazard potential and zoning evaluations in PART II.

PART I

STUDY AREA LOCATION AND PHYSIOGRAPHY

The Mt. Baldy Quadrangle covers an area of about 62 square miles of mostly mountainous terrain that straddles the boundary between Los Angeles and San Bernardino counties. Most of the rugged terrain within the San Gabriel Mountains lies within the Angeles National Forest. Evaluation of landslide hazards is restricted to an area of about 13 square miles of deeply dissected land with moderately steep to steep-sided canyons in the southwestern quarter of the quadrangle. The evaluation extended about one mile into the National Forest in the Los Angeles County portion of the Mt. Baldy Quadrangle. (Federal funding for the program limits the investigation to Los Angeles, Orange, and Ventura counties; therefore, the County of San Bernardino is not covered by the current study.)

Major transportation routes traversing the Mt. Baldy Quadrangle include Euclid, San Antonio and Mountain avenues and Glendora Ridge and Mt. Baldy roads. The San Gabriel Mountains rise very abruptly from the valley and reach elevations of nearly 7000 feet near northern boundary of the quadrangle. The mountains are composed of a complex assemblage of Precambrian through Cretaceous igneous and metamorphic rocks that have been thrust to the south over the adjacent basins.

The major drainage emanating from the San Gabriel Mountains within the area mapped is San Antonio Creek. Sediments eroded from the mountains and deposited in the valley by this drainage and its tributaries have formed a large alluvial fan upon which the City of Claremont now lies. Additional drainages entering the valley include minor streams flowing from Chicken, Palmer, Cobal, Burbank, and Gail canyons.

GEOLOGIC CONDITIONS

Surface and Bedrock Geology

For the Mt. Baldy Quadrangle, a geologic map was compiled from recent mapping by Nourse and others (1998) and digitized by the Southern California Areal Mapping Project [SCAMP] (Morton and Kennedy, 1989). In the field, observations were made of exposures, aspects of weathering, and general surface expression of the geologic units. In addition, the relation of the various geologic units to development and abundance of landslides was noted.

The San Gabriel Mountains are comprised of blocks of plutonic igneous and metamorphic rocks that are being thrust over the San Gabriel Valley from the north. Morton (1975) and Ehlig (1975) mapped the eastern San Gabriel Mountains and the basement rocks south of the San Andreas Fault, respectively, and discussed in detail the placement and composition of the different rock units in the area. Nourse and others (1998) mapped the mountainous areas of the quadrangle, showing the bedrock geology in great detail, and also showing the locations of contacts between crystalline rocks and Quaternary sediments. The map by Nourse and others (1998) separates the crystalline bedrock of the San Gabriel Mountains into units based on age (i.e., Cretaceous, Precambrian, etc.), gross rock type (i.e., granite, granodiorite, etc.), and accessory mineralogy (i.e., pyroxene-biotite granodiorite, hornblende-biotite granodiorite, etc.). The crystalline bedrock of the San Gabriel Mountains was considered as one strength group for slope stability analyses, and therefore, the detail provided in this map was more than that required for the evaluation of landslide potential. Consequently, the map was simplified by grouping similar rock types together, and by including small isolated units with the larger surrounding rock units. For instance, granodiorites and quartz diorites of similar ages were grouped together, regardless of differences in accessory mineralogy, and shown as one unit on the final geologic map. If small dikes or inclusions of different rock were present within the granodiorite unit, they were also shown as part of the granodiorite unit.

Exposed along the southern edge of the mountains is granulitic rock that is mostly cataclastically deformed. Locally referred to as banded rock, it consists of layers of Precambrian gneiss, charnockitic rock, and amphibolite along with Cretaceous biotite granite (pCbgn-Klbgr). Paleozoic metamorphic rocks are exposed west of San Antonio Dam. They consist of a thick sequence of amphibiolite-grade biotite schist (Pzs), quartzite (Pzq), marble (m), and metasedimentary rock (ms+Klbgr, ms+bgn). Locally, these are intruded by Triassic quartz diorite (TRJqd-di, TRJqd-di-pCpbg), Jurassic granodiorite (Jbgd, Jbgd-qm), and Cretaceous rocks of various composition (Kg, Kqd, Kqd+di, Kqd-gd, Kt, Kmg, Klbgr).

The valley areas of the Mt. Baldy Quadrangle are covered by alluvial fans of various ages: active alluvial fan (Qf), younger alluvial fan (Qyf5), older alluvial fan (Qof), and very old alluvial fan (Qvof). A more detailed discussion of the Quaternary deposits in the Mt. Baldy Quadrangle can be found in Section 1.

Geologic Material Strength

To evaluate the stability of geologic materials under earthquake conditions, they first must be ranked based on their overall shear strength. Typically, shear strength data for the rock units identified on the geologic map are obtained from geotechnical reports prepared by consultants on file with local government permitting departments. For the Mt. Baldy Quadrangle shear strength data were obtained from the City of Glendora and the County of Los Angeles (see Appendix A). However, because of the limited number of available shear tests within the Mt. Baldy Quadrangle, the majority of the strength data used were from tests performed on rocks in the adjacent Glendora Quadrangle. The locations of rock and soil samples taken for shear testing are shown on Plate 2.1.

Shear strength data gathered from the above source were compiled for each mapped geologic unit, and subdivided for fine-grained and coarse-grained lithologies if appropriate. Geologic units were grouped on the basis of average angle of internal friction (average f) and lithologic character. The results of the grouping of geologic materials in the Mt. Baldy Quadrangle are in Tables 2.1 and 2.2.

MT. BALDY QUADRANGLE
SHEAR STRENGTH GROUPS STATISTICS

	Formation Name	Number Tests	Mean phi value	Group phi Mean/Median (deg)	Group C Mean/Median (psf)	Map Units Included With This Group	Phi Values: Used in Stability Analyses
Group 1	gr	12	38.5/37.5	38.5/37.5	156/178	Kg, Kqd Kgd+di Kqd-gd, Kt Kmg, Klbgr Jbgd-qm, Jbgd TRJqd-di TRJqd-di-pCpbg Pzq, Pzs ms+Klbgr, m ms+bgn quartzite, bgn pCbgn-Klbgr	38
Group 2	Qa	46	33.7/34.5	33.7/34	294/300	Qa, Qaf Qf, Qfb Qoa, Qof Qt, Qw Qvofb Qvof2b Qyf, Qyf2 Qyf5	34
Group 3	Qls	0					14

gr = all pre-Tertiary crystalline units
Qa = all Quaternary units

Table 2.1. Summary of the Shear Strength Statistics for the Mt. Baldy Quadrangle.

MT. BALDY QUADRANGLE SHEAR STRENGTH GROUPS		
Group 1	**Group 2**	**Group 3**
Kg, Kqd	Qa, Qaf	Qls
Kgd+di	Qf, Qfb	
Kqd-gd, Kt	Qoa, Qof	
Kmg, Klbgr	Qt, Qw	
Jbgd-qm, Jbgd	Qvofb	
TRJqd-di	Qvof2b	
TRJqd-di-pCpbg	Qyf, Qyf2	
Pzq, Pzs	Qyf5	
ms+Klbgr, m		
ms+bgn		
quartzite, bgn		
pCbgn-Klbgr		

Table 2.2. Summary of the Shear Strength Groups for the Mt. Baldy Quadrangle.

Landslide Inventory

The evaluation of earthquake-induced landsliding requires an up-to-date and complete picture of the previous occurrence of landsliding. An inventory of existing landslides in the Mt. Baldy Quadrangle was prepared by reviewing published maps and reports showing or discussing landslides, such as Streitz (1967), Morton and Streitz (1969), and Bortugno and Spittler (1986) and combining field observations, analysis of aerial photos (see References for list of air photos used), and interpretation of landforms on current and older topographic maps. The landslide inventory map was digitized and information on confidence of interpretation (definite, probable, or questionable) and other properties, such as activity, thickness, and associated geologic units was compiled in a database. A version of this landslide inventory is included with Plate 2.1.

PART II

EARTHQUAKE-INDUCED LANDSLIDE GROUND SHAKING OPPORTUNITY

Design Strong-Motion Record

The Newmark analysis used in delineating the earthquake-induced landslide zones requires the selection of a design earthquake strong-motion record. For the Mt. Baldy Quadrangle, selection of a strong motion record was based on an estimation of probabilistic ground motion parameters for modal magnitude, modal distance, and peak ground acceleration (PGA). The parameters were estimated from maps prepared by

DMG for a 10% probability of being exceeded in 50 years (Petersen and others, 1996; Cramer and Petersen, 1996). The parameters used in the record selection are:

Modal Magnitude:	7 to 7.3
Modal Distance:	2.5 to 4.5
PGA:	0.68 to 0.77 g

The strong-motion record selected for the slope stability analysis in the Mt. Baldy Quadrangle was the SMIP Corralitos record from the magnitude 6.9 (M_w) 1989 Loma Prieta earthquake (Shakal and others, 1989). This record had a source to recording site distance of 5.1 km and a peak ground acceleration (PGA) of 0.64 g. The selected strong-motion record was not scaled or otherwise modified prior to its use in the analysis.

Displacement Calculation

To develop a relationship between the yield acceleration (a_y; defined as the horizontal ground acceleration required to cause the factor of safety to equal 1.0) and Newmark displacements, the design strong-motion record was integrated twice for a given a_y to find the corresponding displacement, and the process repeated for a range of a_y values (Jibson, 1993). The resulting curve in Figure 2.1 represents the full spectrum of displacements that can be expected for any combination of geologic material strength and slope angle, as represented by the yield acceleration.

We used displacements of 30, 15 and 5 cm as criteria for rating levels of earthquake shaking damage on the basis of the work of Youd (1980), Wilson and Keefer (1983), and the DMG pilot study for earthquake-induced landslides (McCrink and Real, 1996). Applied to the curve in Figure 2.1, these displacements correspond to yield accelerations of 0.086, 0.133 and 0.234g. Because these yield acceleration values are derived from the design strong-motion record, they represent the ground shaking opportunity thresholds that are significant to the Mt. Baldy Quadrangle.

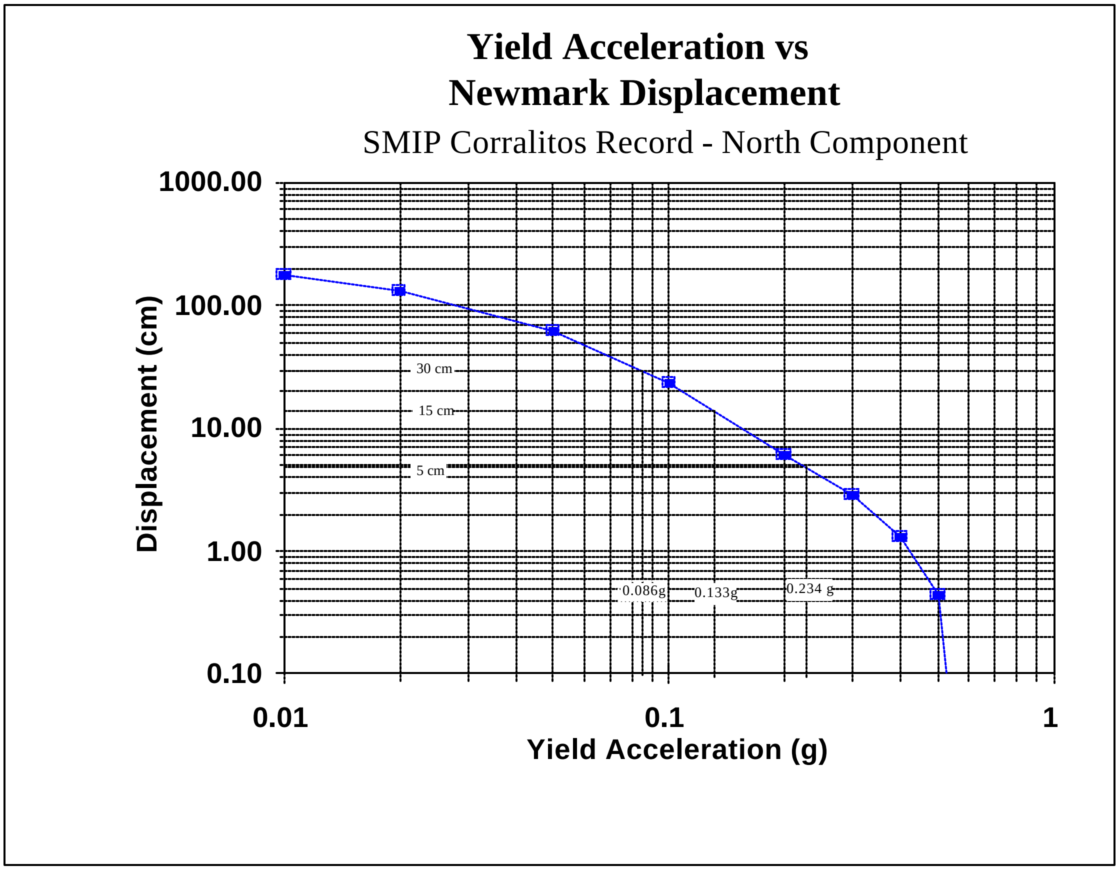

Figure 2.1. **Yield Acceleration vs. Newmark Displacement for the 1989 Loma Prieta Earthquake Corralitos Record. Record from California Strong Motion Instrumentation Program (CSMIP) Station 57007.**

EARTHQUAKE-INDUCED LANDSLIDE HAZARD POTENTIAL

Terrain Data

The calculation of slope gradient is an essential part of the evaluation of slope stability under earthquake conditions. To calculate slope gradient for the terrain within the Mt. Baldy Quadrangle, a Level 2 digital elevation model (DEM) was obtained from the USGS (U.S. Geological Survey, 1995). This DEM, which was prepared from the 7.5-minute quadrangle contours, has a 10-meter horizontal resolution and a 7.5-meter vertical accuracy. Surrounding quadrangle DEMs were merged with the Mt. Baldy DEM to avoid the loss of data at the quadrangle edges when the slope calculations were performed. A peak and pit smoothing process was then performed to remove errors in the elevation points.

To update the topographic base map, areas that have undergone large-scale grading as a part of residential development in the hilly portions of the Mt. Baldy Quadrangle were identified. Using 1:40,000-scale NAPP photography taken in 1994 and 1995, photogrammetric DEMs covering the graded areas were prepared by the U.S. Bureau of Reclamation with ground control obtained by DMG. The photogrammetric DEMs were then merged into the USGS DEM, replacing the areas of outdated elevation data. Plate 2.2 shows those areas where the topography is updated to 1994-95 grading conditions.

A slope-gradient map was made from the combined DEMs using a third-order, finite difference, center-weighted algorithm (Horn, 1981). This map was used in conjunction with the geologic strength map in preparation of the earthquake-induced landslide hazard potential map.

Stability Analysis

A slope stability analysis was performed for each geologic material strength group at slope increments of 1 degree. An infinite-slope failure model under unsaturated slope conditions was assumed. A factor of safety was calculated first, followed by the calculation of yield acceleration from Newmark's equation:

$$a_y = (FS - 1)g \sin \alpha$$

where FS is the Factor of Safety, g is the acceleration due to gravity, and α is the direction of movement of the slide mass, in degrees measured from the horizontal, when displacement is initiated (Newmark, 1965). For an infinite slope failure α is the same as the slope angle.

The yield acceleration calculated by Newmark's equations represents the susceptibility to earthquake-induced failure of each geologic material strength group for a range of slope gradients. The acceleration values were compared with the ground shaking opportunity, defined by Figure 2.1, to determine the earthquake-induced landslide hazard potential. Based on the criteria described in Figure 2.1 above, if the calculated yield acceleration was less than 0.086g, expected displacements could be greater than 30 cm, and a HIGH (H on Table 2.3) hazard potential was assigned. Likewise, if the calculated a_y fell between 0.086 and 0.133g a MODERATE (M on Table 2.3) hazard potential was assigned, between 0.133 and 0.234g a LOW (L on Table 2.3) potential was assigned, and if a_y were greater than 0.234g a VERY LOW (VL on Table 2.3) potential was assigned.

Table 2.3 summarizes the results of the stability analyses. The earthquake-induced landslide hazard potential map was prepared by combining the geologic material-strength map and the slope map according to this table.

Mt. Baldy Quadrangle
Hazard Potential Matrix

Geologic Material Strength	SLOPE GRADIENT CATEGORY I 0 to 11% 0 to 6°	II 12 to 17% 7 to 9°	III 18 to 42% 10 to 22°	IV 43 to 52% 23 to 27°	V 53 to 61% 28 to 31°	VI 62 to 69% 32 to 34°	VII > 69% >34°
Group 1	VL	VL	VL	VL	L	M	H
Group 2	VL	VL	VL	L	M	H	H
Group 3	L	M	H	H	H	H	H

Table 2.3. Hazard Potential Matrix for Earthquake-Induced Landslides in the Mt. Baldy Quadrangle. Shaded area indicates hazard potential levels included within the hazard zone.

EARTHQUAKE-INDUCED LANDSLIDE ZONE

Criteria for Zoning

Earthquake-induced landslide zones were delineated using criteria adopted by the California State Mining and Geology Board (1996). Under those criteria, earthquake-induced landslide zones are areas meeting one or both of the following:

1. Areas identified as having experienced landslide movement in the past (including all mappable landslide deposits and source areas), and, where possible, areas known to have experienced earthquake-induced landsliding during historic earthquakes.

2. Areas where geologic and geotechnical data and analyses indicate that the earth materials may be susceptible to earthquake-induced slope failure.

Existing Landslides

Studies of the types of landslides caused by earthquakes (Keefer, 1984) show that re-activation of the whole mass of deep-seated landslide deposits is rare. However, it has been observed that the steep scarps and toe areas of existing landslides, which formed as a result of previous landslide movement, are particularly susceptible to earthquake-induced slope failure. In addition, because they have been disrupted during landslide movement, landslide deposits are inferred to be weaker than coherent, undisturbed, adjacent source rocks. Finally, we felt that a long duration, San Andreas fault-type earthquake could be capable of initiating renewed movement in existing deep-seated landslide deposits. Therefore, all existing landslides identified in the inventory with a definite or probable confidence of interpretation were included in the hazard zone.

Geologic and Geotechnical Analysis

On the basis of a DMG pilot study (McCrink and Real, 1996) the earthquake-induced landslide zone includes all areas determined to lie within the High, Moderate and Low levels of hazard potential. Therefore, as shown in Table 2.3, geologic strength group 3 is always included in the zone (mapped landslides); strength group 2 above 42%; and strength group 1, the strongest rock types, were zoned for slope gradients above 52%. This results in roughly 9% of the land in the quadrangle lying within the hazard zone representing 36.5% of the area mapped.

ACKNOWLEDGMENTS

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AIR PHOTOS

CDMG AP Project, January 1953 to October 1954 Aerial Photographs, series AXJ, flight 9K, frames 140-144, and 108-115, flight 21K, frames 31-36, Series AXL, flight 39K, frames 105-113, and 152-162, flight 40K, frames 03-09, and 51-52, flight 50K, frames 92-94, black and white, vertical, approximate scale 1:20000/27000.

USGS (U.S. Geological Survey), NAPP Aerial Photography, May 28, 1994, flight 6851, frames 151-152, June 1, 1994, flight 6866, frame 123, and November 1, 1995, flight 6874, frame 89, black and white, vertical, approximate scale 1:40000.

APPENDIX A
SOURCES OF ROCK STRENGTH DATA

SOURCE	NUMBER OF TESTS SELECTED
City of Glendora, Engineering Div. of Public Works	**41**
Los Angeles County Public Works Department	**37**
Total number of tests used to characterize the units in the Mt. Baldy Quadrangle	**78**

SECTION 3
GROUND SHAKING EVALUATION REPORT

Potential Ground Shaking in the Mt. Baldy 7.5-Minute Quadrangle, Los Angeles County, California

By

Mark D. Petersen, Chris H. Cramer, Geoffrey A. Faneros, Charles R. Real, and Michael S. Reichle

California Department of Conservation
Division of Mines and Geology

PURPOSE

The Seismic Hazards Mapping Act (the Act) of 1990 (Public Resources Code, Chapter 7.8, Division 2) directs the California Department of Conservation, Division of Mines and Geology (DMG) to delineate Seismic Hazard Zones. The purpose of the Act is to reduce the threat to public health and safety and to minimize the loss of life and property by identifying and mitigating seismic hazards. Cities, counties, and state agencies are directed to use the Seismic Hazard Zone Maps in their land-use planning and permitting processes. The Act requires that site-specific geotechnical investigations be performed prior to permitting most urban development projects within the hazard zones. Evaluation and mitigation of seismic hazards are to be conducted under guidelines established by the California State Mining and Geology Board (1997; also available on the Internet at http://www.consrv.ca.gov/dmg/pubs/sp/117/).

This section of the evaluation report summarizes the ground motions used to evaluate liquefaction and earthquake-induced landslide potential for zoning purposes. Included, are ground motion and related maps, a brief overview on how these maps were prepared, precautionary notes concerning their use, and related references. The maps provided herein are presented at a scale of approximately 1:150,000 (scale bar provided on maps), and show the full 7.5- minute quadrangle and portions of the adjacent eight quadrangles.

They can be used to assist in the specification of earthquake loading conditions ***for the analysis of ground failure*** according to the “Simple Prescribed Parameter Value” method (SPPV) described in the site investigation guidelines (California State Mining and Geology Board, 1997). Alternatively, they can be used as a basis for comparing levels of ground motion determined by other methods with the statewide standard.

This section and Sections 1 and 2, addressing liquefaction and earthquake-induced landslide hazards, constitute a report series that summarizes development of seismic hazard zone maps in the state. Additional information on seismic hazard zone mapping in California can be accessed on DMG’s Internet homepage:
http://www.consrv.ca.gov/dmg/shezp/

EARTHQUAKE HAZARD MODEL

The estimated ground shaking is derived from the seismogenic sources as published in the statewide probabilistic seismic hazard evaluation released cooperatively by the California Department of Conservation, Division of Mines and Geology, and the U.S. Geological Survey (Petersen and others, 1996). That report documents an extensive 3-year effort to obtain consensus within the scientific community regarding fault parameters that characterize the seismic hazard in California. Fault sources included in the model were evaluated for long-term slip rate, maximum earthquake magnitude, and rupture geometry. These fault parameters, along with historical seismicity, were used to estimate return times of moderate to large earthquakes that contribute to the hazard.

The ground shaking levels are estimated for each of the sources included in the seismic source model using attenuation relations that relate earthquake shaking with magnitude, distance from the earthquake, and type of fault rupture (strike-slip, reverse, normal, or subduction). The published hazard evaluation of Petersen and others (1996) only considers uniform firm-rock site conditions. In this report, however, we extend the hazard analysis to include the hazard of exceeding peak horizontal ground acceleration (PGA) at 10% probability of exceedance in 50 years on spatially uniform conditions of rock, soft rock, and alluvium. These soil and rock conditions approximately correspond to site categories defined in Chapter 16 of the Uniform Building Code (ICBO, 1997), which are commonly found in California. We use the attenuation relations of Boore and others (1997), Campbell (1997), Sadigh and others (1997), and Youngs and others (1997) to calculate the ground motions.

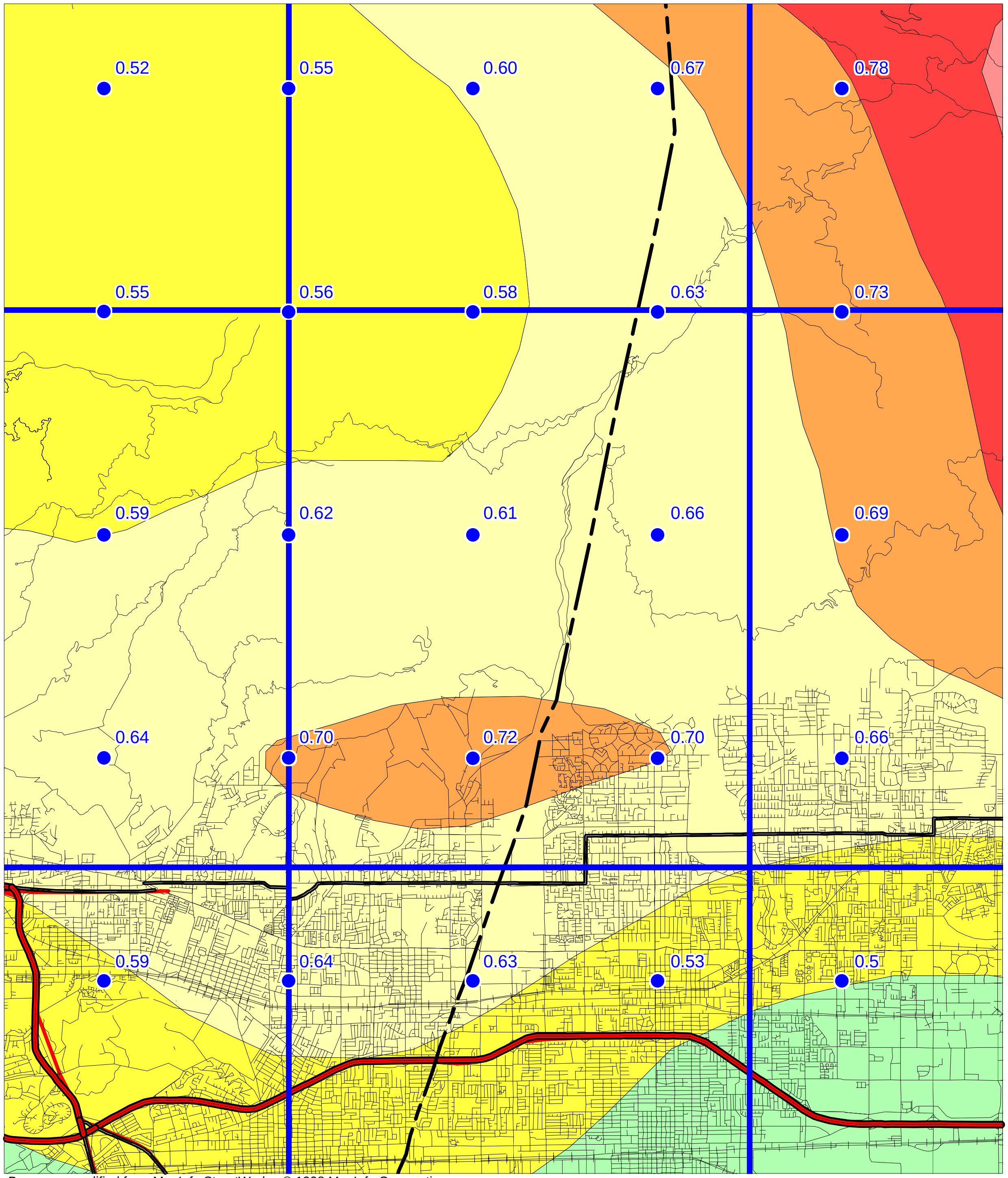
The seismic hazard maps for ground shaking are produced by calculating the hazard at sites separated by about 5 km. Figures 3.1 through 3.3 show the hazard for PGA at 10% probability of exceedance in 50 years assuming the entire map area is firm rock, soft rock, or alluvial site conditions respectively. The sites where the hazard is calculated are represented as dots and ground motion contours as shaded regions. The quadrangle of interest is outlined by bold lines and centered on the map. Portions of the eight adjacent

MOUNT BALDY 7.5 MINUTE QUADRANGLE AND PORTIONS OF ADJACENT QUADRANGLES

10% EXCEEDANCE IN 50 YEARS PEAK GROUND ACCELERATION (g)

1998

FIRM ROCK CONDITIONS



Base map modified from MapInfo StreetWorks © 1998 MapInfo Corporation

0 2.5 5
Kilometers

Department of Conservation
Division of Mines and Geology

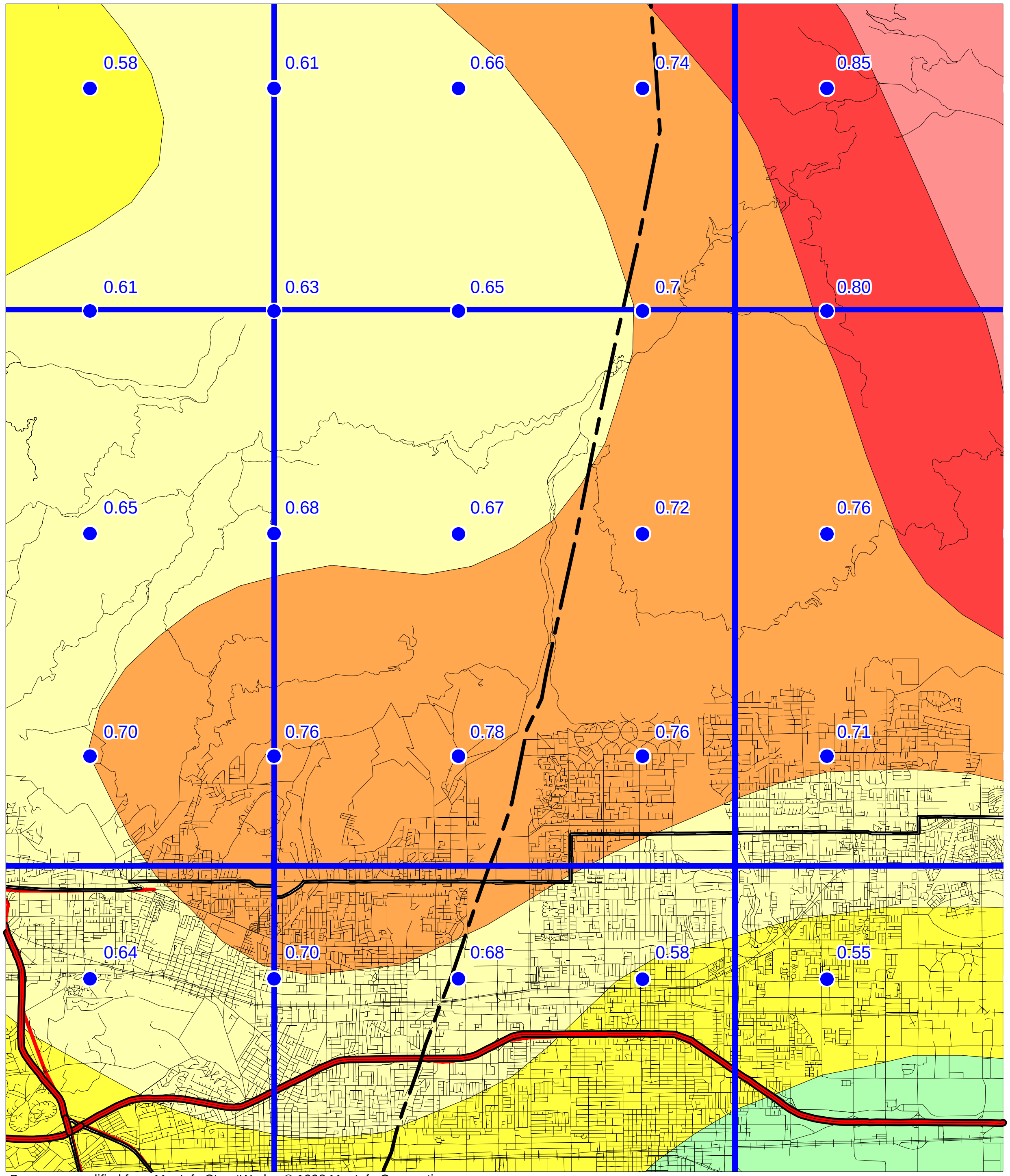
Figure 3.1

MT. BALDY 7.5 MINUTE QUADRANGLE AND PORTIONS OF ADJACENT QUADRANGLES

10% EXCEEDANCE IN 50 YEARS PEAK GROUND ACCELERATION (g)

1998

SOFT ROCK CONDITIONS



Base map modified from MapInfo StreetWorks © 1998 MapInfo Corporation

0 2.5 5

Kilometers

Department of Conservation
Division of Mines and Geology

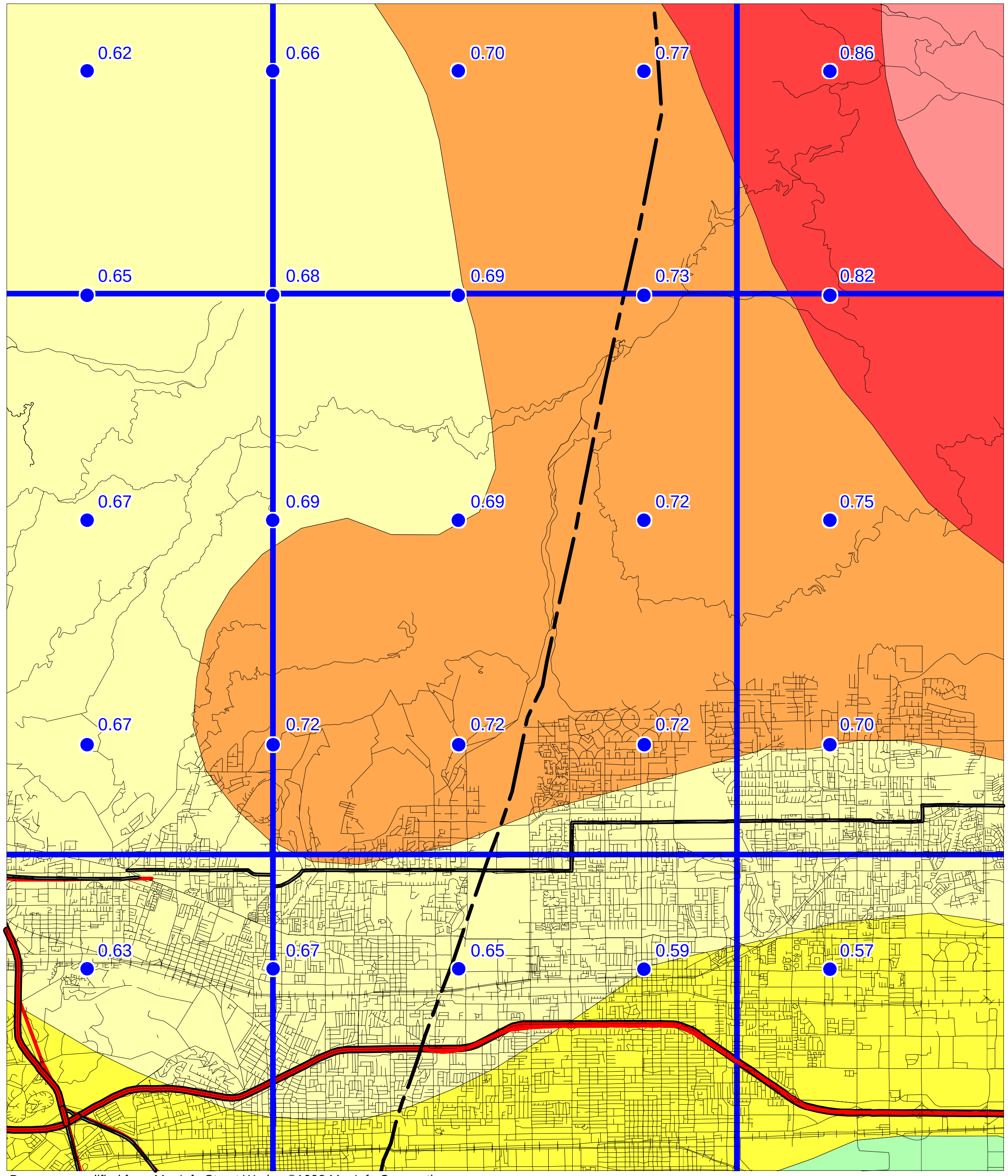
Figure 3.2

MT. BALDY 7.5 MINUTE QUADRANGLE AND PORTIONS OF ADJACENT QUADRANGLES

10% EXCEEDANCE IN 50 YEARS PEAK GROUND ACCELERATION (g)

1998

ALLUVIUM CONDITIONS



Base map modified from MapInfo Street Works ©1998 MapInfo Corporation

0 2.5 5
Kilometers

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Figure 3.3

quadrangles are also shown so that the trends in the ground motion may be more apparent. We recommend estimating ground motion values by selecting the map that matches the actual site conditions, and interpolating from the calculated values of PGA rather than the contours, since the points are more accurate.

APPLICATIONS FOR LIQUEFACTION AND LANDSLIDE HAZARD ASSESSMENTS

Deaggregation of the seismic hazard identifies the contribution of each of the earthquakes (various magnitudes and distances) in the model to the ground motion hazard for a particular exposure period (see Cramer and Petersen, 1996). The map in Figure 3.4 identifies the magnitude and the distance (value in parentheses) of the earthquake that contributes most to the hazard at 10% probability of exceedance in 50 years on alluvial site conditions (*predominant earthquake*). This information gives a rationale for selecting a seismic record or ground motion level in evaluating ground failure. However, it is important to keep in mind that more than one earthquake may contribute significantly to the hazard at a site, and those events can have markedly different magnitudes and distances. For liquefaction hazard the predominant earthquake magnitude from Figure 3.4 and PGA from Figure 3.3 (alluvium conditions) can be used with the Youd and Idriss (1997) approach to estimate cyclic stress ratio demand. For landslide hazard the predominant earthquake magnitude and distance can be used to select a seismic record that is consistent with the hazard for calculating the Newmark displacement (Wilson and Keefer, 1983). When selecting the predominant earthquake magnitude and distance, it is advisable to consider the range of values in the vicinity of the site and perform the ground failure analysis accordingly. This would yield a range in ground failure hazard from which recommendations appropriate to the specific project can be made. Grid values for predominant earthquake magnitude and distance should **not** be interpolated at the site location, because these parameters are not continuous functions.

USE AND LIMITATIONS

The statewide map of seismic hazard has been developed using regional information and is ***not appropriate for site specific structural design applications***. Use of the ground motion maps prepared at larger scale is limited to estimating earthquake loading conditions for preliminary assessment of ground failure at a specific location. We recommend consideration of site-specific analyses before deciding on the sole use of these maps for several reasons.

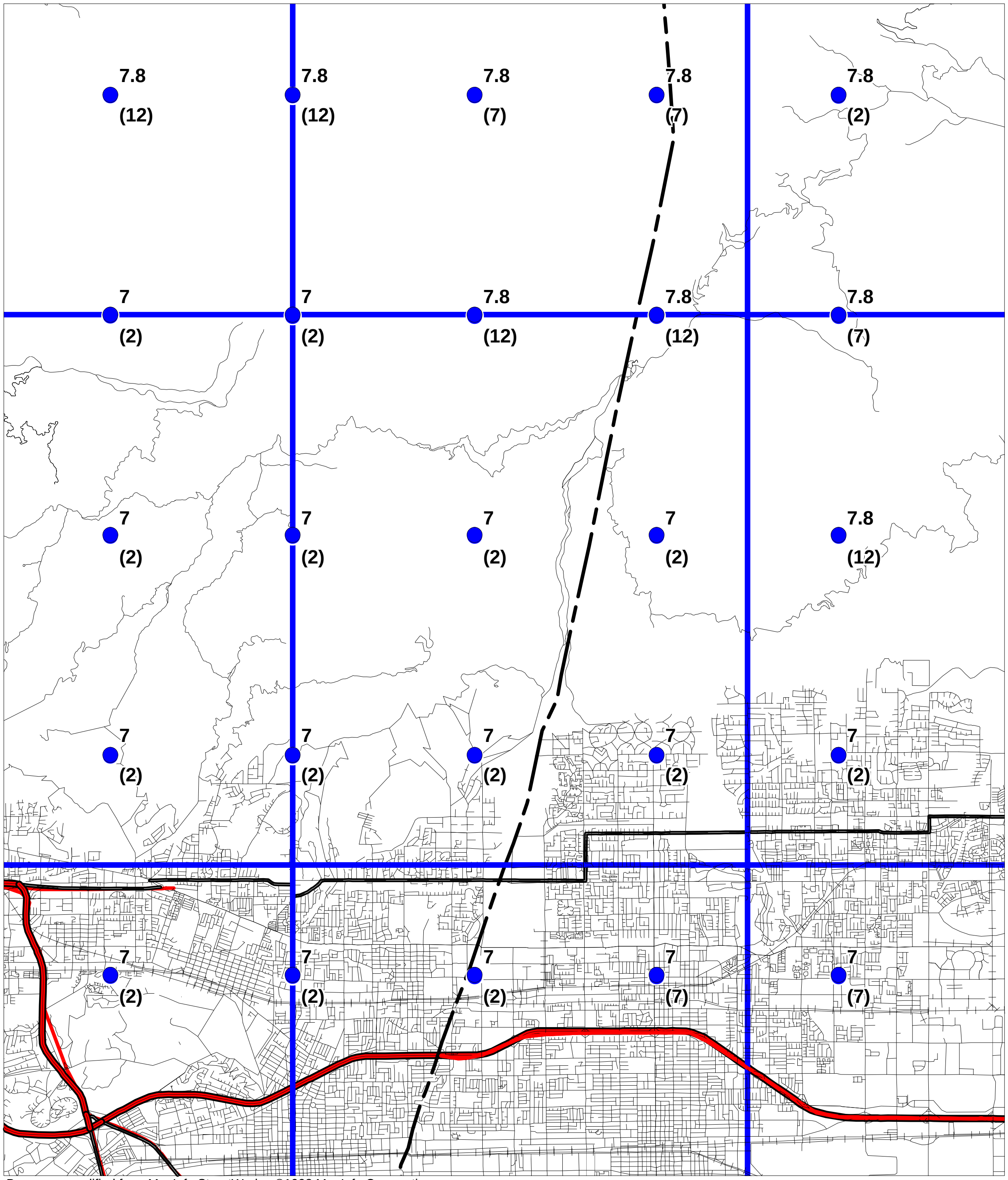
1. The seismogenic sources used to generate the peak ground accelerations were digitized from the 1:750,000-scale fault activity map of Jennings (1994). Uncertainties in fault location are estimated to be about 1 to 2 kilometers (Petersen and others, 1996). Therefore, differences in the location of calculated hazard values may also differ by a similar amount. At a specific location, however, the log-linear attenuation

MOUNT BALDY 7.5 MINUTE QUADRANGLE AND PORTIONS OF ADJACENT QUADRANGLES

10% EXCEEDANCE IN 50 YEARS PEAK GROUND ACCELERATION

1998

PREDOMINANT EARTHQUAKE
Magnitude (Mw)
(Distance (km))



Base map modified from MapInfo StreetWorks ©1998 MapInfo Corporation

0 2.5 5
Kilometers

Department of Conservation
Division of Mines and Geology

Figure 3.4

of ground motion with distance renders hazard estimates less sensitive to uncertainties in source location.

2. The hazard was calculated on a grid at sites separated by about 5 km (0.05 degrees). Therefore, the calculated hazard may be located a couple kilometers away from the site. We have provided shaded contours on the maps to indicate regional trends of the hazard model. However, the contours only show regional trends that may not be apparent from points on a single map. Differences of up to 2 km have been observed between contours and individual ground acceleration values. *We recommend that the user interpolate PGA between the grid point values rather than simply using the shaded contours*.

3. Uncertainties in the hazard values have been estimated to be about +/- 50% of the ground motion value at two standard deviations (Cramer and others, 1996).

4. Not all active faults in California are included in this model. For example, faults that do not have documented slip rates are not included in the source model. Scientific research may identify active faults that have not previously been recognized. Therefore, future versions of the hazard model may include other faults and omit faults that are currently considered.

5. A map of the predominant earthquake magnitude and distance is provided from the deaggregation of the probabilistic seismic hazard model. However, it is important to recognize that a site may have more than one earthquake that contributes significantly to the hazard. Therefore, in some cases earthquakes other than the predominant earthquake should also be considered.

Because of its simplicity, it is likely that the SPPV method (California State Mining and Geology Board, 1997) will be widely used to estimate earthquake shaking loading conditions for the evaluation of ground failure hazards. It should be kept in mind that ground motions at a given distance from an earthquake will vary depending on site-specific characteristics such as geology, soil properties, and topography, which may not have been adequately accounted for in the regional hazard analysis. Although this variance is represented to some degree by the recorded ground motions that form the basis of the hazard model used to produce Figures 3.1, 3.2, and 3.3, extreme deviations can occur. More sophisticated methods that take into account other factors that may be present at the site (site amplification, basin effects, near source effects, etc.) should be employed as warranted. The decision to use the SPPV method with ground motions derived from Figures 3.1, 3.2, or 3.3 should be based on careful consideration of the above limitations, the geotechnical and seismological aspects of the project setting, and the “importance” or sensitivity of the proposed building with regard to occupant safety.

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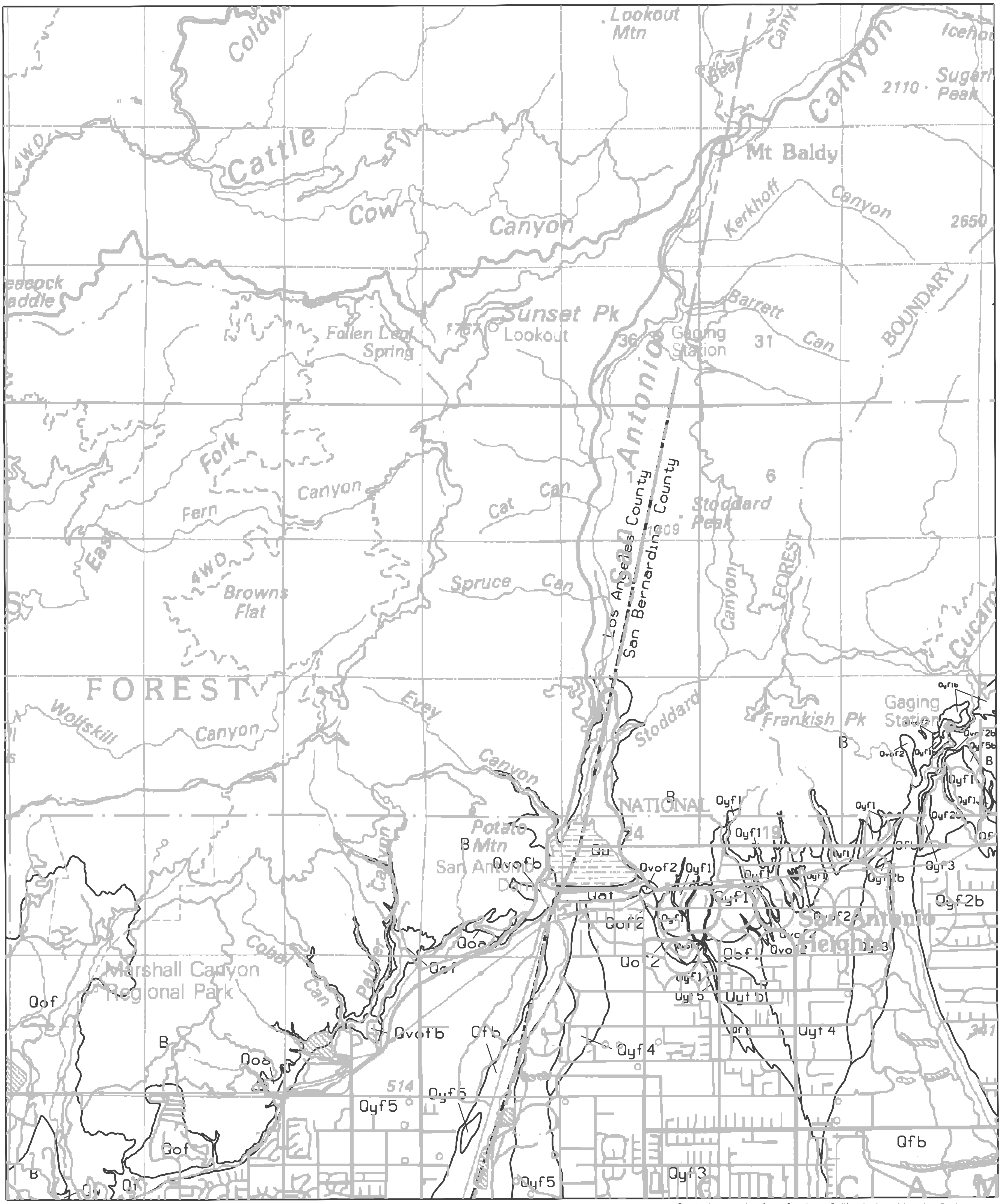


Base map enlarged from U.S.G.S. 30 x 60–minute series

Geologic mapping from Southern California Area Mapping Project, 1999

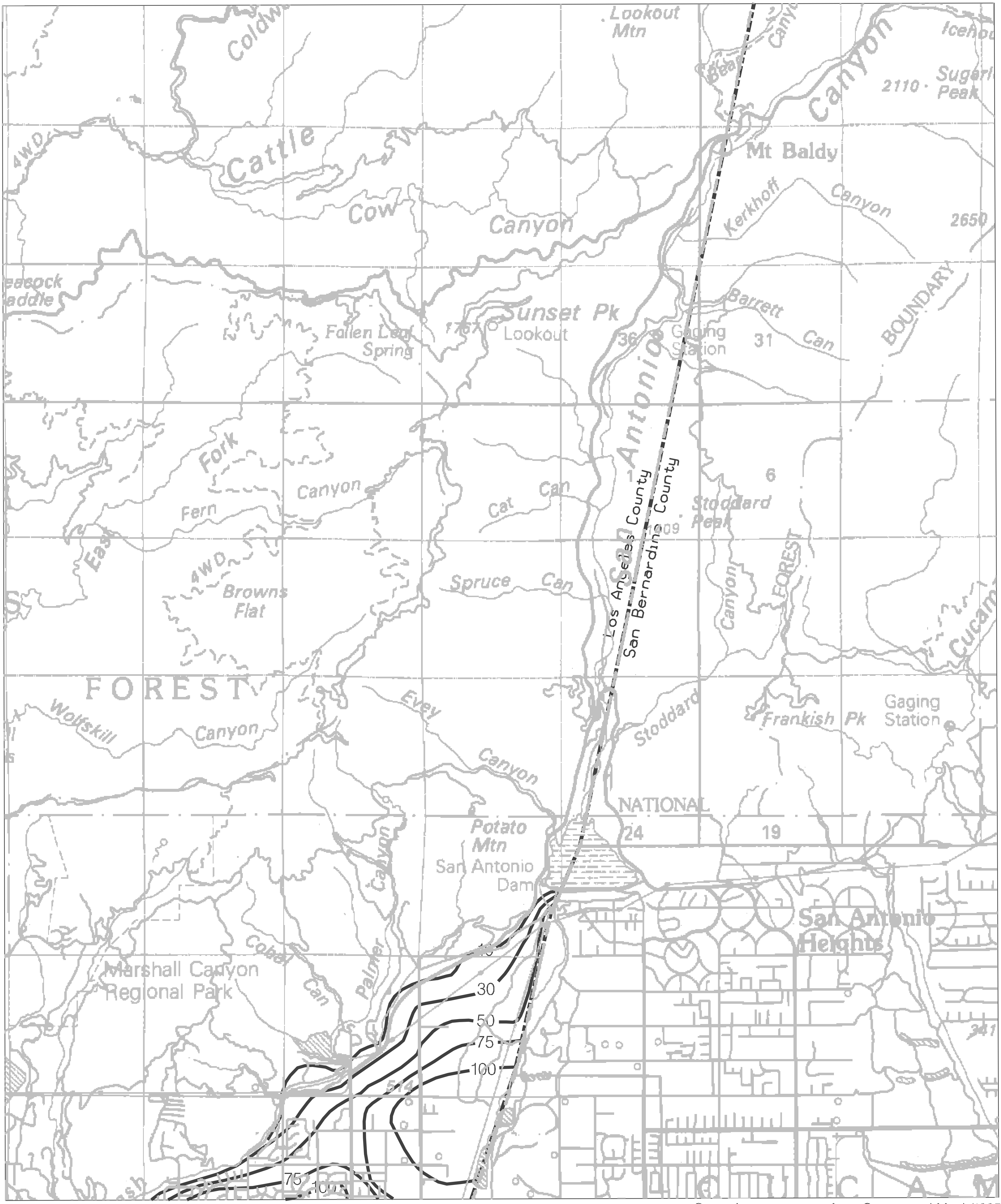
Plate 1.1 Quaternary Geologic Map of the Mt. Baldy Quadrangle (valley area only).

See Geologic Conditions section in report for descriptions of the units.

B = Pre–Quaternary bedrock.

ONE MILE

Scale



Base map enlarged from U.S.G.S. 30 x 60–minute series

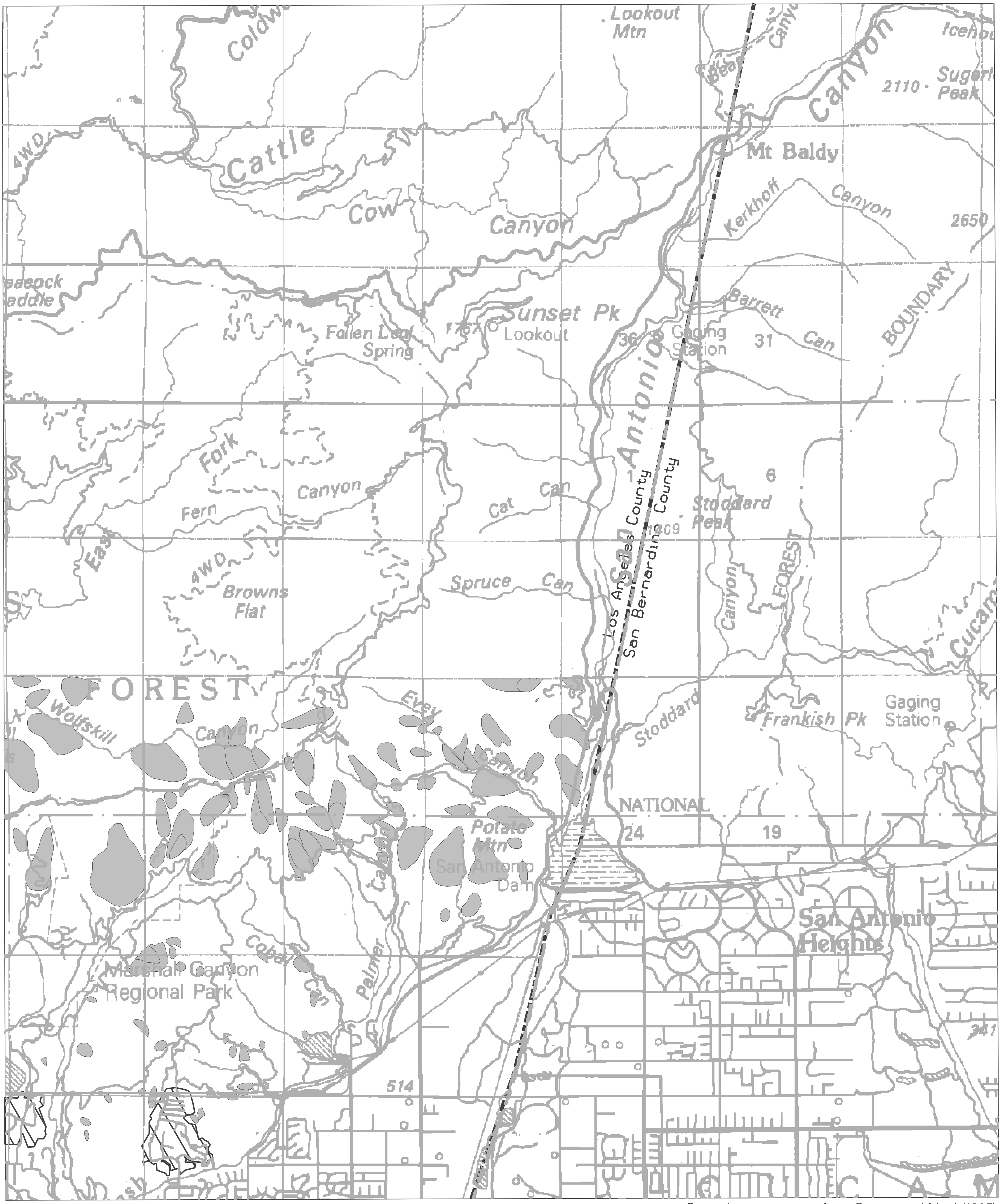
Groundwater contours from Carson and Matti (1985)

Plate 1.2 Historically Highest Ground Water Levels in the Los Angeles County Part of the Mt. Baldy Quadrangle.

30 Depth to ground water in feet

ONE MILE

Scale



Base map enlarged from U.S.G.S. 30 x 60–minute series

Groundwater contours from Carson and Matti (1985)

Plate 2.1 Landslide inventory, Shear Test Sample Locations, Mt Baldy Quadrangle.

landslide

areas of significant grading

ONE MILE

SCALE